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MEASUREMENT GROUP

MODEL VISHAY/ELLIS 40

INSTRUCTION MANUAL

V/E-40

DECADE RESISTOR

(STRAIN GAGE SIMULATOR)

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1.0 GENERAL

The V/E-40 is a special-purpose resistive decade box specifically designed to achieve high accuracy increments of resistance down to 0.01 ohms. Its primary application is the simulation of resistive strain gages for instrument calibration and the investigation of accuracy problems associated with the strain indicators and the necessary wiring between the gage and the instrument.

The V/E-40 can, of course, be used as a standard "decade box" for general electrical purposes, although the lower limit of 30.00 ohms and limited current capacity may be considerations in certain circumstances.

Due to the special circuits used (which limit the lower resistance to 30.00 ohms), the reproducibility of readings on the lower three dacades (1, 0.1, and 0.01 ohms) is exceptionally good; this is not as true of the 10 and 100 ohm decades so that altering these settings should only be done when necessary if high reproducibility of prior settings is essential.

All critical resistors are Vishay® Bulk Metal® types, featuring exceptionally good stability, temperature coefficient and rise time.

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2.0 SPECIFICATIONS:

2.1 Range and Decades: 30.00 to 1111.10 ohms, direct reading.
5 decades: 100, 10, 1, 0.1, and 0.01 ohms/step. All decades 11 position (10% overrange).

2.2 Absolute Accuracy: Total resistance: 0.02% of setting.

2.3 Incremented Accuracy:

Decade	Max. error per step
100Ω/step	0.1% (0.1Ω)
10	0.1% (0.01Ω)
1	0.1% (0.001Ω)
0.1	0.15% (o.00015Ω)
0.01	1.5% (0.00015Ω)

2.4 Repeatability:

Decade	Ohms
100Ω/step	0.001
10	0.001
1	0.0001
0.1	0.0001
0.01	0.0001

2.5 Temperature coefficient of resistance: 3 ppm/°C

2.6 Current Capacity (Rated power at 25°C)

Setting Ohms	Max Current mA
30.00 - 59.99	120
60.00 - 89.99	100
90.00 - 99.99	75
(90.00 - 139.99)*	(75)*
90.00 - 199.99	65
200.00 - 399.99	55
400.00 - 699.99	30
700.00 - 1111.10	25

*Applies only when 100Ω/step decade is set at "0"
(See Paragraph 3.5 for more detailed information)

2.7 Size and Weight

Case Size: 3-1/8" W x 9-1/8" L x 2-5/8" H (3-7/8" overall height) [80mm W x 232mm L x 67mm H (98mm overall height)]

Weight: 1.9 lbs. [0.85kg]

3.0 OPERATION

3.1 Reading the Dials:

At most settings the value in ohms is obtained by simply reading the in-line display of white numbers against the black squares, as follows:

Decade: 100Ω	10Ω	1Ω	0.1Ω	0.01Ω	Value
0	4	6	.4	3	46.43Ω
8	7	4	.9	0	874.90Ω
0	12	6	.1	4	126.14Ω

It will be noticed that, when moving the 100Ω/step decade from "0" to "1" the reading on the 10Ω/step dial is reduced by 3 (i.e., 30Ω) due to a movement to the outer set of markings on the 10Ω/step dial. This is because the first step is 70Ω (not 100Ω) to correct for the 30Ω built-in resistance of the V/E-40.

All decades have a 10% (1-step) overrange capability. When any decade (except the 100Ω/step decade) is set at "10", the in-line display must NOT be read exactly as seen; the user must mentally carry the "1" to the next decade to the left. For example:

Decade: 100Ω	10Ω	1Ω	0.1Ω	0.01Ω	Value
6	4	10	.3	5	650.35Ω
6	4	7	.10	5	648.05Ω
6	4	10	.10	5	651.05Ω
6	4	9	.9	10	650.00Ω

3.2 Unmarked Position of Decade Switches:

All decade switches (except 100Ω/step) have continuous rotation, but operation at the unmarked position is not recommended. If any dial is in the unmarked position, the total reading becomes relatively indeterminate, although precautions have been taken so that it will not be an open circuit. For reference, the actual value for unmarked position is tabulated below.

Decade	Value
10Ω/Step	50Ω ±5%
1	10Ω
0.1	1Ω
0.01	0.10Ω

3.3 Accuracy, Repeatability, and Stability

The user must appreciate that any decade resistor has four largely independent qualities which are often (although incorrectly) collectively called the "accuracy".

a. Accuracy of Setting: The amount (in percent or ohms) by which the measured resistance at any setting differs from the total of all dial readings. This is principally controlled by the precision of the individual resistors used at the setting. At low total resistances the switch contact resistance may become significant also.

b. Incremental (ΔR) Accuracy: The amount (in ohms, or percent of the intended ΔR) by which the actual difference between two setting differs from the difference of the two dial readings. Thus ΔR accuracy is controlled only by the precision of the individual resistor(s) involved in the change of settings. If the ΔR is small, the variability of switch contact resistance may be significant.

c. Repeatability: The amount (generally expressed in ohms) by which the measured resistance differs when any dial reading is set on the dial, then the dials are moved and returned to the same setting; this procedure would be done several times. Assuming reasonably stable resistors, regardless of accuracy, this would be controlled exclusively by the switches and the circuit in which they are used.

d. Stability: The amount (generally expressed in percent or ppm) by which the measured resistance changes with time, temperature, or environment while

leaving the dials undisturbed. This is principally controlled by the quality or type of resistors used.

The design of the V/E-40 has optimized each of the above qualities individually within economic and size limitations, with special emphasis on ΔR accuracy and repeatability for ΔR's in the range of 0.01 to 10 ohms. A necessary compromise to achieve these special features was to limit the minimum settable resistance to 30.00 ohms.

3.4 Contact Repeatability:

The three least-significant decades (1Ω, 0.1Ω, 0.01Ω) employ a special shunt circuit to essentially eliminate the effect of switch contact resistance or the repeatability of these switches. While efforts have been made to minimize the overall effect of contact resistance and its variation associated with the 10Ω and 100Ω decades, operation of these switches may measurably destroy the ability to exactly reproduce the original total resistance (typically in the order of 1 or 2 milliohms in a new V/E-40).

Accordingly, there are some situations in which the user must plan ahead or make unusual dial changes so that a small ΔR can be introduced with maximum accuracy, maintaining the ability to repeat the original reading; the problem usually occurs with negative changes. For example:

a. Initial resistance: 120.00Ω
Required ΔR: -0.10Ω

Initial setting:	1	1	9	.10	0	(120.00Ω)
New setting:	1	1	9	.9	0	(119.90Ω)
or						
Initial setting:	1	1	10	.0	0	(120.00Ω)
New setting:	1	1	9	.9	0	(119.90Ω)

b. Initial resistance: 350.00Ω
   Required ΔR: +10Ω

Initial Setting:	3	5	0	.0	0	(350.00Ω)
New Setting:	3	5	10	.0	0	(360.00Ω)

Note that, with planning, changes of +11.1Ω or -10.0Ω can be made from a properly set initial value which is an integral multiple of 10Ω, while still preserving the ability to very precisely repeat the initial value. However, the initial setting for +ΔR is different from that required for -ΔR, so that ±ΔR's are limited to +1.1, -10.0Ω from these cardinal initial values.

3.5 Current and Power Limits.

The V/E-40 uses special VISHAY® Bulk Metal® resistors, noted for their low (and highly predictable) temperature coefficient and excellent stability.

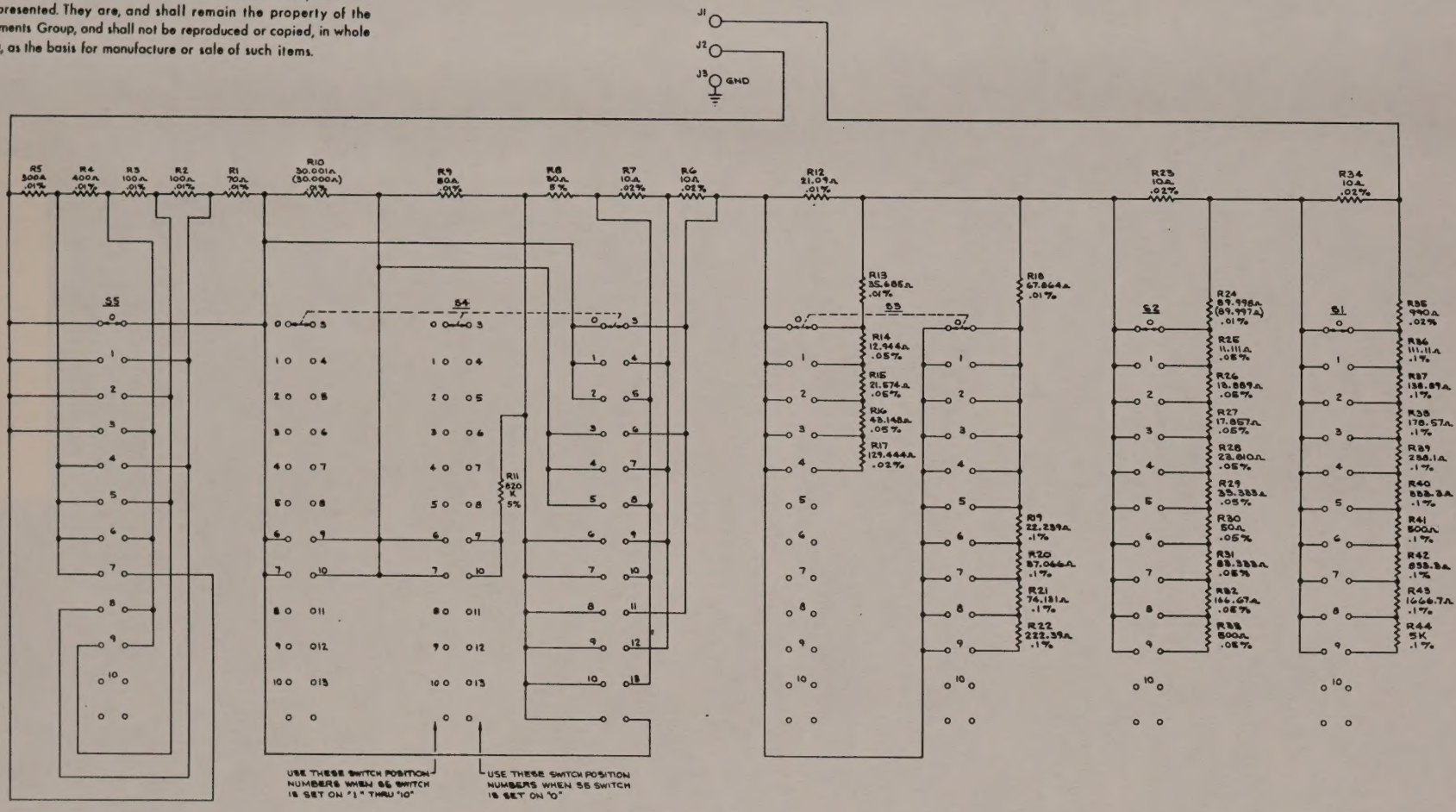
While each individual resistor is rated at 0.3 watts at 25°C ambient, the current (and thus total power) rating at any setting of the V/E-40 is generally determined by one particular resistor. Since the V/E-40 uses a combination of modified 11-position resistor strings and modified BCD networks on the various decades, it is difficult to fully describe the current or power ratings in concise tabular form. Thus the data given in Section 2.7, while correct for worst-case situations, is amplified by Figures 3.1 and 3.2, below. It will be noted that the V/E-40 can, in general, be described as a 1/2 to 1 watt device, depending on setting, although there are some exceptions both above and below these figures.

Two other remarks are pertinent:

a. Between 100 and 140 ohms, significantly higher power can be dissipated if the 100Ω/step dial is set at "0" and the 10Ω/step dial is set at 10, 11, 12, or 13, as required.

b. When the 10Ω/step dial is set at "10", the current and voltage "drops" at 90, 100, 400, and 700Ω are moved to the right by 10Ω, thus slightly improving power dissipation at and just above these values.

These drawings and specifications are intended to provide information for the proper utilization or maintenance or calibration or repair of the items represented. They are, and shall remain the property of the Measurements Group, and shall not be reproduced or copied, in whole or in part, as the basis for manufacture or sale of such items.



NOTES:

1. ALL RESISTORS ARE RATED 0.3 WATTS.
2. RESISTANCE VALUES ALLOW FOR 0.003Ω CONTACT RESISTANCE PER SWITCH CIRCUIT AND A TOTAL BUS RESISTANCE TO BINDING POSTS OF 0.004Ω.
3. RESISTANCE VALUES ARE MARKED VALUES ALLOWING FOR LEAD RESISTANCE. (VALUES IN PARENTHESIS ARE EFFECTIVE INSTALLED RESISTANCE, IF DIFFERENT)

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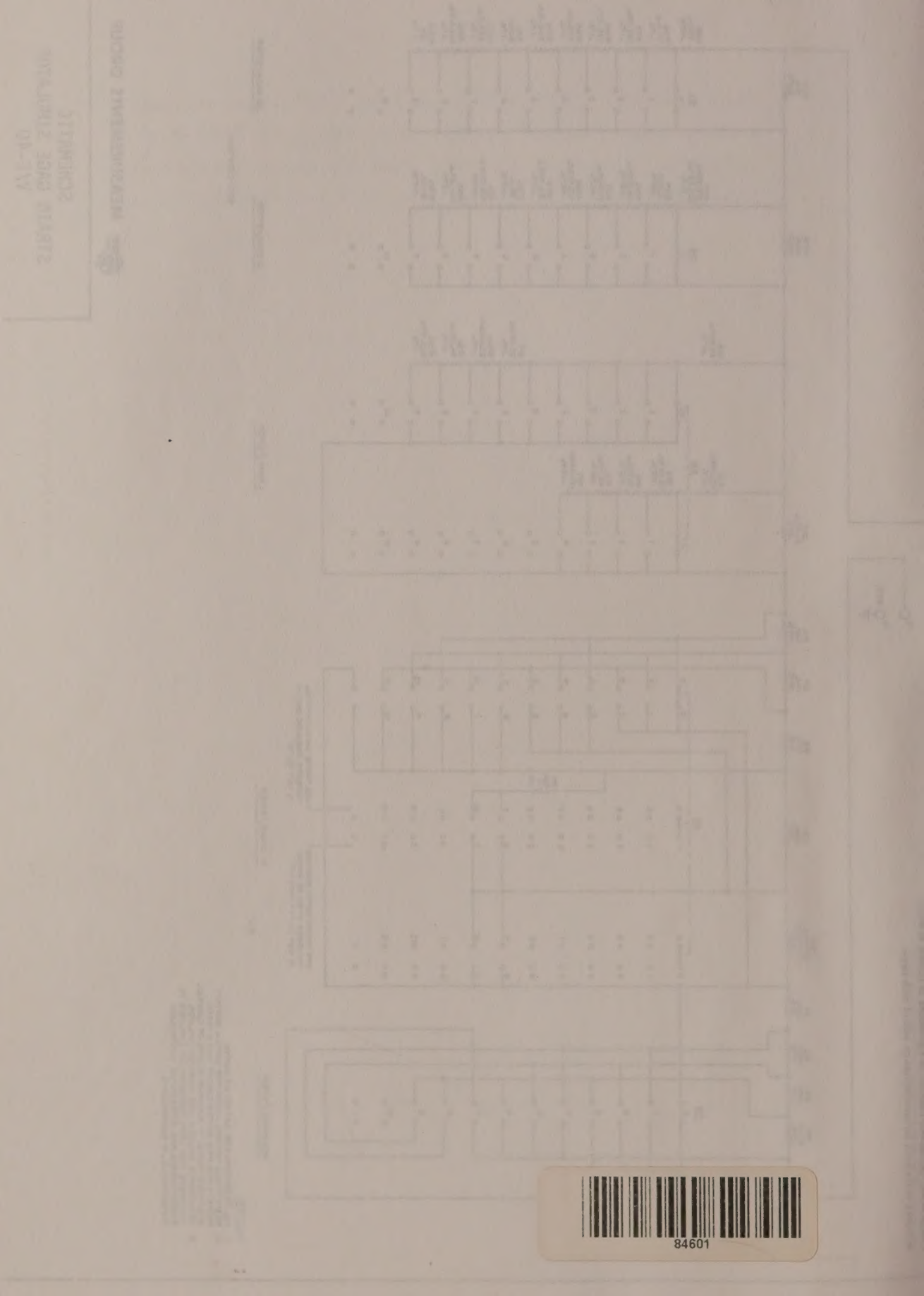
MEASUREMENTS GROUP

SCHEMATIC
STRAIN GAGE SIMULATOR
V/E-40



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